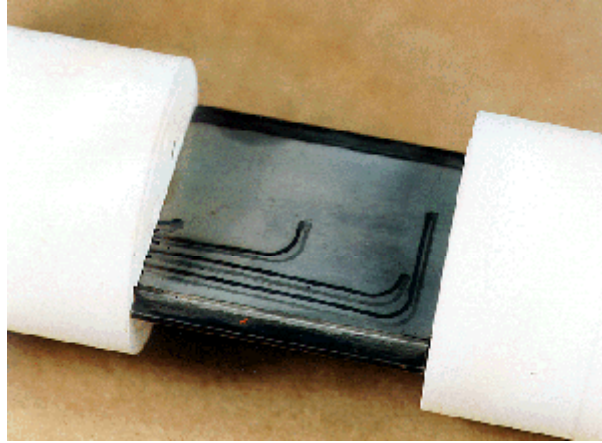


# Thin-Film Thermocouple Technology Demonstrated for Reliable Heat Transfer Measurements



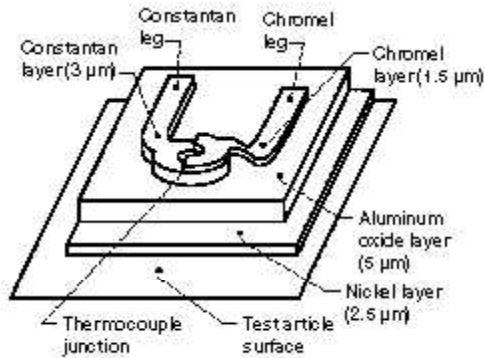
*Test article instrumented with four thin-film thermocouples.*

Exploratory work is in progress to apply thin-film thermocouples to localized heat transfer measurements on turbine engine vanes and blades. The emerging thin-film thermocouple technology shows great potential to improve the accuracy of local heat transfer measurements. With conventional imbedded thermocouples, heat-transfer measurements on the thin walls of cooled turbine blades have a high uncertainty because of unavoidable flow and heat-path perturbations caused by the bulky thermocouples and lead wires. Thin-film thermocouples offer an ideal solution for blade and vane surface temperature measurements because they guarantee virtually no perturbation of the heat path and blade wall thickness or of the coolant and gas flow patterns. However, early attempts to use thin-film sensors were not fully successful mainly because of problems with the thin-film-to-lead-wire connections.

To verify and master the experimental methodology of thin-film thermocouples, the NASA Lewis Research Center conducted a proof-of-concept experiment in a controlled environment before applying the thin-film sensors to turbine tests. The test article consisted of a flat plate with an internally cooled narrow passage submerged into a stream of heated air. Both the externally heated side and the internally cooled side were instrumented with thin-film sensors. A typical thin-film thermocouple sensor and the instrumented test article are shown in the figures. A major problem with applying thin films to electrically conducting metal surfaces is the necessity to insulate the sensor from the substrate. We accomplished this by modifying the aluminum oxide layer. Another crucial aspect of thin-film sensor reliability is the connection between the thin-film thermocouple legs and the lead wires that link the sensors with data-acquisition equipment. In our approach, the sputtered thermocouple legs were first connected to bare 25-micrometer thermocouple alloy wires, which were then connected to 0.25-mm

insulated thermocouple lead wires. This approach proved highly reliable; no thermocouple was lost during testing.

Initial tests were conducted at Mach 0.4 and at a static temperature of 425 K on the heated side and at Mach 0.5 and a static temperature of 280 K on the cooled side; the heat flow rate was  $200 \text{ kW/m}^2$ . Lewis is preparing work with partners from industry on applying the thin-film thermocouples to turbine blades for temperature measurements up to 700 K and to turbine vanes for temperatures up to 1000 K.



*Thin-film thermocouple (type E).*

## Bibliography

Lepicovsky, J.; Bruckner, R.J; and Smith, F.A.: Application of Thin-Film Thermocouples to Localized Heat Transfer Measurements. AIAA Paper 95-2834 (NASA TM-107045), 1995.